Equations $T(p,h)$, $v(p,h)$ and $T(p,s)$, $v(p,s)$ for the Critical and Supercritical Regions of Water

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The International Association for the Properties of Water and Steam (IAPWS) has decided to develop equations for the backward functions $T(p,h)$, $v(p,h)$ and $T(p,s)$, $v(p,s)$ for the critical and supercritical regions of water (region 3 of IAPWS-IF97). The equation set, developed at the University of Applied Sciences of Zittau and Goerlitz and at the Technical University of Dresden, will be presented. The equations have been accepted and are being evaluated by IAPWS. They are provided as a supplement to the Industrial Formulation IAPWS-IF97 [1] and to the additional standard IAPWS-2001 [2].

The numerical consistencies of the new equations with the IAPWS-IF97 basic equation are lower than the required permissible values. To fulfill the required numerical consistency, the range of validity has been divided into two subregions. The subregion boundary between the subregions is the critical entropy. The deviations between the backward equations of the adjacent subregions are smaller than the numerical consistencies with the IAPWS-IF97 equations. Furthermore, the critical temperature and the critical volume are exactly met by the equations.

Since the numerical consistency of the equation set with IAPWS-IF97 is sufficient for most applications in heat cycle and steam turbine calculations, the otherwise necessary iterations can be avoided. Therefore, calculations of temperature and specific volume from pressure and enthalpy or from pressure and entropy using the equations presented are more than 15 times faster than IAPWS-IF97.

The basis for developing the backward equations is a special approximation algorithm, which was developed at the Technical University of Dresden and at the University of Applied Sciences of Zittau and Goerlitz [3]. The algorithm is based on the structure optimization method of Wagner.

[1] W. Wagner et al., *Journal of Engineering for Gas Turbines and Power* **122**, 150 (2000).
[2] H.-J. Kretzschmar et al., *Journal of Engineering for Gas Turbines and Power,* in preparation.
[3] J. Tr¸benbach, *Fortschr.-Ber. VDI Reihe* ***6*****,** 417 (1999).